

**Nashville crayfish**  
**(*Orconectes shoupi*)**

**5-Year Review:**  
**Summary and Evaluation**



Photo by: Michelle Barbero, Metro Water Services

**U.S. Fish and Wildlife Service**  
**Southeast Region**  
**Tennessee Ecological Services Field Office**  
**Cookeville, Tennessee**

## 5-YEAR REVIEW

### Nashville crayfish/*Orconectes shoupi*

#### I. GENERAL INFORMATION

##### A. Methodology used to complete the review

This 5-year review was completed by the lead recovery biologist in our Tennessee Ecological Services Field Office (TFO). In conducting this 5-year review, we relied on the best available information pertaining to historical and current distribution, life history, and habitat of this species. The specific sources of information used in this analysis were found in the final rule listing this species under the Endangered Species Act (Act); the recovery plan; peer reviewed scientific publications; unpublished field observations by the Fish and Wildlife Service (Service), State and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts.

We announced initiation of this review and requested information in a notice published in the *Federal Register* on September 21, 2007 (72 FR 54057). We received no information or comments from the public in response to this announcement during the 60-day comment period. The completed draft review was sent to various Federal and State government agencies, universities, and others who might have information about the species. Peer reviewers were asked to provide comments and any relevant information about the threats and status of the species. Comments were evaluated and incorporated as appropriate into this 5-year review (see Appendix C). We received valuable input from the Nashville Zoo, Tennessee Department of Environment and Conservation (TDEC), and the Tennessee Wildlife Resources Agency (TWRA).

##### B. Reviewers

**Lead Region - Southeast Region:** Kelly Bibb; 404/679-7132

**Lead Field Office - Tennessee Ecological Services Field Office:** Steve Alexander; 931/525-4980

##### C. Background

1. **Federal Register Notice announcing initiation of this review:**  
September 21, 2007, 72 FR 54057
2. **Species status:** Stable. Recent surveys have indicated persistence of the species in highly developed areas of Metropolitan Nashville.
3. **Recovery achieved:** 1 (1 = 0-25% species' recovery objectives achieved)
4. **Listing history**  
Original Listing  
FR notice: 51 FR 34410  
Date listed: October 27, 1986

Entity listed: species  
Classification: endangered

**5. Associated rulemakings:** None

**6. Review history:**

Each year the Service reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we did a recovery data call that included showing status recommendations of “Stable” for this crayfish. We continue to show that species status recommendation in 5-year reviews. The most recent evaluation for Nashville crayfish was completed in 2016.

Recovery Plan: 1989

Five Year Review: November 6, 1991.

In this review (56 FR 56882), different species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors as they pertained to the different species’ recovery. In particular, no changes were proposed for the status of this crayfish in the review.

**7. Species’ Recovery Priority Number at start of review (48 FR 43098):**

11C – A priority number of 11C indicates a moderate degree of threat, low recovery potential, taxonomic level of species, and the presence of conflict with construction, development, or other economic activities.

**8. Recovery plan:**

Name of plan: Nashville Crayfish Recovery Plan

Date issued: August 12, 1987

Date of revision: February 8, 1989

## **II. REVIEW ANALYSIS**

### **A. Application of the 1996 Distinct Population Segment (DPS) policy**

The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is a crayfish, the DPS policy is not applicable.

### **B. Recovery Criteria**

- 1. Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes. The criteria are somewhat objective

yet need more clarity with the additional information that we have learned on this crayfish.

**2. Adequacy of recovery criteria**

- a. **Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** No. Since approval of the revised recovery plan, studies have provided new information about the species' habitat, biology, and historical range.
- b. **Are all of the five listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?** Yes, the recovery criteria address habitat degradation and restricted range, the two factors that formed the basis of our listing determination. However, we have new information concerning the species' historical range and the degree of threat to the continued existence of the species resulting from increased development in the Mill Creek drainage.

**3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

The recovery plan indicates that removal of the Nashville crayfish from the Act protection is unlikely. The following are criteria that must be met before reclassification of the species to threatened status can be considered.

1. *Through protection of the existing Mill Creek basin population and by reintroduction of the species into some as yet unknown historical habitat or by discovery of an additional distinct population, there exist two distinct viable populations.*

This criterion has been partially met due to implementation of monitoring of water quality and, where needed, initiation of enforcement actions by state and local agencies to ensure the protection of the existing Mill Creek Basin population (recovery task 1.1). However, we believe this criterion is not achievable given the best available information concerning the range of the species.

The best available information indicates that the Nashville crayfish is endemic to the Mill Creek drainage (See Distribution under section C(1)(d)). Because only one historical population is known to have existed, the criterion of two distinct viable populations is not appropriate, as it would require introducing the species to waters outside of its known historical range.

2. *A newly discovered or reintroduced population must: (a) have been established or be self-sustaining for a minimum of 10 years without augmentation from an outside source, (b) represent a significant component of the crayfish fauna throughout most of that creek, and (c) be stable or increasing in numbers and range.*

This criterion has not been met and is likely unachievable. There have been no newly discovered populations outside of the Mill Creek watershed nor is the species likely to be discovered in other watersheds.

Additionally, new populations of the species have not been reintroduced. The best information available at this time indicates that the Nashville crayfish is endemic to the Mill Creek drainage (See Distribution under section C(1)(d)). Until such time as a population of the species is discovered outside of the Mill Creek drainage, and because Service policy does not allow for establishment of populations of listed species outside their historical ranges, establishment of a second population in another drainage as a recovery criterion is not appropriate.

3. *The species and its habitat in the Mill Creek system and one other system are protected from human-related and natural threats that would be likely to cause the species' extinction in the foreseeable future.*

This criterion has been partially met in the Mill Creek system. Until such time that a population of the species is discovered outside of the Mill Creek drainage, protections to the species and its habitat are concentrated within the Mill Creek drainage.

Service biologists have worked with other agencies, groups, and individuals to protect the species and its habitat from human-related threats. During project reviews for routine U.S. Army Corps of Engineers Section 404 permits and TDEC Aquatic Resource Alteration Permits (ARAPs), recommended measures to protect the species are included as permit conditions.

Formal section 7 consultations are also completed for more complex projects. We routinely interact with Metro Water Services on stormwater best management practices and compliance activities for project developments in the watershed. The TFO is also actively involved with non-governmental organizations (NGOs) in dam removal projects in the watershed. However, because of its location within and in close proximity to Metropolitan Nashville, the Mill Creek drainage is under increasing pressure from and is being affected

by residential, commercial, and industrial development. (See Section 2. Five Factor Analysis).

### C. Updated Information and Current Species Status

#### 1. Biology and Habitat

##### a. Abundance, population trends, or demographic trends:

Many authors have addressed the particular characters that distinguish the Nashville crayfish from others in Mill Creek and the region (Hobbs 1948; O'Bara et al. 1985; USFWS 1989; Williams 2001). The most distinguishing features include elongate pincers with red tips and adjacent narrow black banding, a usually light-colored "saddle" on the carapace extending from the posterior to the anterior and terminating as lateral stripes on either side, and distinctive gonopods markedly different from any of its congeners. Larger females can be identified easily by the sigmoidal cleft of the annulus ventralis (AV or sperm receptacle) under minimal magnification, and occasionally by the naked eye. Such identification presumes that the AV is not occluded by debris or is particularly melanic.

The Nashville crayfish (*O. shoupi*) can be a rather large crayfish, ranging from young-of-the-year (YOY) at ~0.6 cm total length (TL) to adults ~17.8 cm (TDNA 2009, O'Bara et al., 1985). Other *Orconectes* reported from the Mill Creek watershed, including *O. rhoadesi* and *O. durrelli*, easily can be distinguished from *O. shoupi* by gonopod structure and body coloration. As noted by Bouchard (1984a), *O. placidus*, a Central Basin species strongly resembling *O. shoupi*, never has been reported from the Mill Creek watershed. As such, even YOY crayfish from the Mill Creek drainage often can be identified comfortably as *O. shoupi*, as no other saddle-bearing species are present in the system. That idea was borne out during a contemporary distributional survey (TDNA 2009), as the only adult *Orconectes* from the Mill Creek system with the characteristic saddle was *O. shoupi*. Saddled YOY observed in the Mill Creek drainage, by inference, are likely *O. shoupi* as well (TDNA 2009).

The Nashville crayfish persists in Mill Creek and its tributaries despite heavy development that has occurred in Metropolitan Nashville and surrounding areas. Some stream reaches still contain relatively high densities of the species. A study done in 1999-2000 (Carpenter 2002a) determined densities and delineated the distribution of the species. Mill Creek was sampled at regular intervals from its confluence with the Cumberland River to its source; tributaries in which the species was found were also surveyed at regular intervals, and the length of tributary reaches occupied were identified. Data were collected from all Nashville crayfish collected, and individuals were marked. The result of mark/recapture sampling revealed population numbers of Nashville crayfish in Sevenmile Creek to be 404-1,425 individuals per 100 linear meters of stream. Estimates for Mill Creek were 1,854-3,217 individuals per 100 linear meters.

Long-term population monitoring for this species is important to determine the status of the species over time. The Nashville Zoo developed and implemented long-term monitoring protocols for the species in the Mill Creek watershed. Five monitoring sites were identified, including 3 main stem Mill Creek sites and 2 tributaries (Table 1). Habitat parameters were evaluated initially at all 5 monitoring sites so that habitat perturbations at any site which might affect those parameters in the future could be detected. Comprehensive site evaluations were completed during September and October of 2012. The first round of population surveys were conducted by Nashville Zoo staff during the month of September 2012. Long-term monitoring efforts by Nashville Zoo personnel continued through 2015.

**Table 1. Long-term Monitoring Sites**

<b>Mill Creek Mile 5.5:</b>	<b>Davidson County</b>	<b>(N 36.12335 W 86.72446)</b>
<b>Mill Creek Mile 13.6:</b>	<b>Davidson County</b>	<b>(N 36.05727 W 86.67019)</b>
<b>Mill Creek Mile 22.6:</b>	<b>Williamson County</b>	<b>(N 35.97173 W 86.68131)</b>
<b>Indian Creek Mile 1.1:</b>	<b>Davidson County</b>	<b>(N 36.00877 W 86.66960)</b>
<b>Sims Branch Mile 1.1:</b>	<b>Davidson County</b>	<b>(N 36.15024 W 86.68254)</b>

Additional data were collected on various parameters at each site, some of which include: habitat patch size, water quality parameters, substrate type, and level of sedimentation. With this data, additional statistical analysis can be run in the future to determine correlations with variable factors and crayfish occupancy. The protocols, as written, will allow the determination of fluctuating population levels over time and determine long term population trends at the Mill Creek proper sites where the Nashville crayfish is the predominant species. The sampling protocols were not sensitive enough to detect statistically significant low numbers of the Nashville crayfish when there are large numbers of other crayfish species present at the sampling site. This was found to be the case for the two tributary study sites that were included in the monitoring protocols. A modified catch per unit effort (CPUE) for tributaries to approximate Nashville crayfish densities over time is in development.

Based on the initial results of long-term monitoring population surveys, monitoring twice per year was discontinued. After 5 years of monitoring once a year, compiled data will be evaluated to determine if the protocols should be modified again to reduce surveying events to every other year. Barring a sampling bias towards larger streams, significant numbers of Nashville crayfish at a particular site and discovery of the species in previously undocumented tributaries of Mill Creek could indicate that the species has expanded within its known range and is tolerating impacts to its habitat.

**b. Genetics, genetic variation, or trends in genetic variation:**

There have been no genetic analyses conducted on the Nashville crayfish since the Recovery Plan was revised in 1989; however, we established a cooperative

agreement in FY 2015 with Tennessee Technological University to begin this effort.

**c. Taxonomic classification or changes in nomenclature:**

*Orconectes shoupi* Hobbs 1948 is the recognized classification of the Nashville crayfish. Hobbs described *O. shoupi* following close examination of a series of crayfishes from the Nashville area (Bouchard, 1984, from Barrociere, 1986). No other changes in nomenclature have occurred.

**d. Spatial distribution, trends in spatial distribution, or historical range (e.g. corrections to the historical range, change in distribution of the species' within its historical range, etc.):**

The Nashville crayfish is endemic to the Mill Creek watershed in Davidson and Williamson Counties, Tennessee. There has been no change in the distribution of the species within its historical range (USFWS unpublished data).

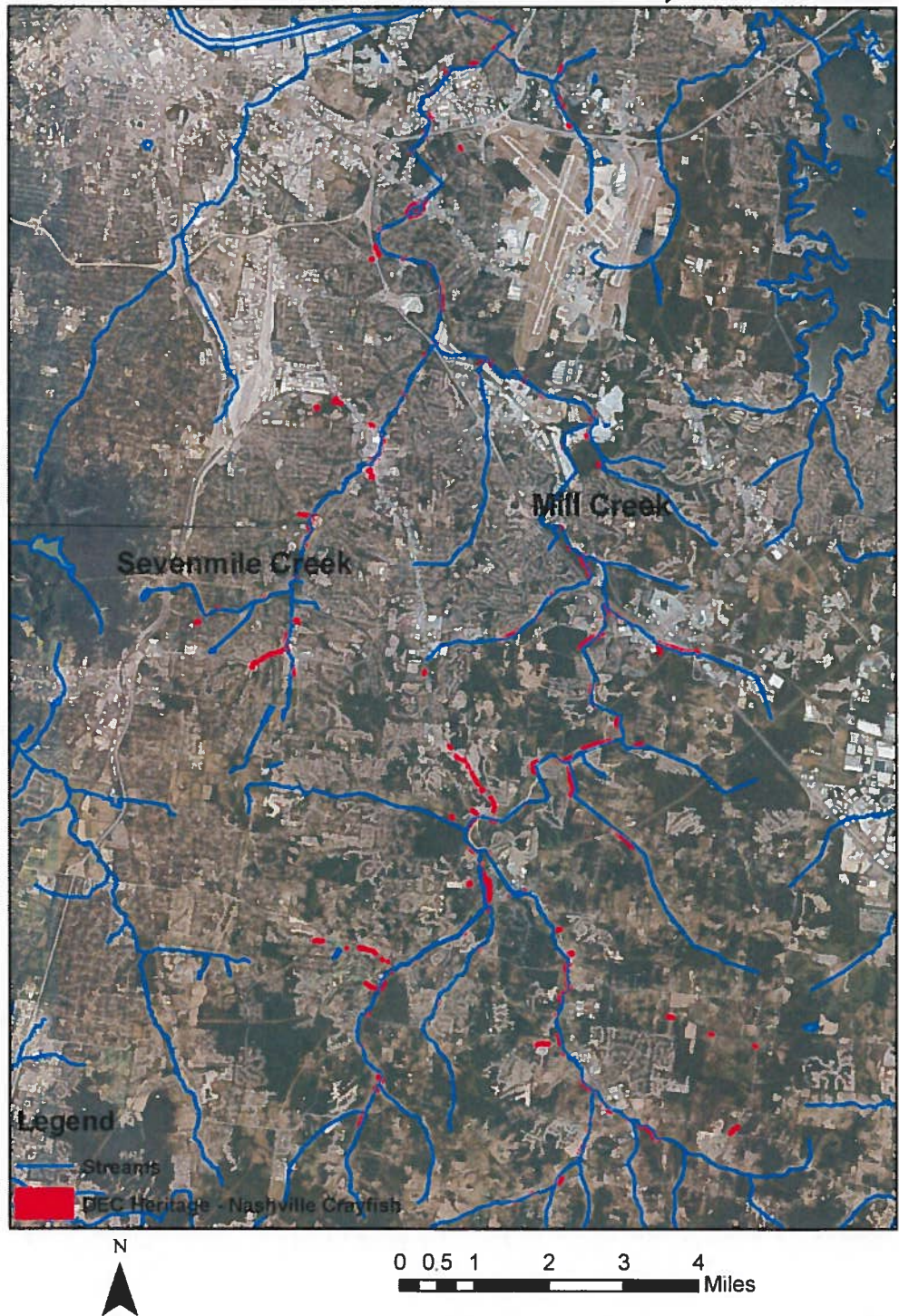
The Nashville crayfish is currently known only from Mill Creek and its tributaries (Figure 1). The species may have occurred historically in Big Creek in Giles County (Elk River drainage), the South Harpeth River in Davidson County (Harpeth River drainage), and Richland Creek in Davidson County (Cumberland River drainage) (USFWS 1987). The Big Creek and South Harpeth River records are believed to be the result of "bait bucket" introductions. The species was thought to be native to Richland Creek, but was displaced by a more competitive crayfish species. However, specimens of Nashville crayfish (*Orconectes shoupi*) collected from Richland Creek were misidentified and the collections were annotated as the bigclaw crayfish (*Orconectes placidus*) (USFWS 1989).

Biologists conducting the pre-listing status survey for the species surveyed 148 streams in central Tennessee (Korgi and O'Bara 1985). Streams surveyed were located in the Collins River drainage, Stones River drainage, Caney Fork River drainage, Cumberland River drainage, Red River drainage, Mill Creek drainage, Harpeth River drainage, and Elk River drainage. Nashville crayfish were only found in Mill Creek and its tributaries.

In 1999, a study was done to determine the current status of the Nashville crayfish in the Mill Creek watershed and to identify potential habitat in stream systems adjacent to Mill Creek (O'Bara 2000). The species was found in Mill Creek, except in the lower 0.8-mile reach which is influenced by water level fluctuations in the Cumberland River and in the upper 2.5-mile reach which undergoes seasonal dewatering. The species was found to be evenly distributed in the remaining 23.5 miles of Mill Creek. Nashville crayfish were also found in eight of the 15 tributaries to Mill Creek.



**Figure 1. Nashville Crayfish Distribution  
Davidson and Williamson Counties, Tennessee**



Fifty-two streams in the adjacent Harpeth River, Cumberland River, and Stones River watersheds were evaluated as potential habitats for the species. Several

streams provided good to excellent habitat for the species; however, it was not known that Nashville crayfish would use non-riverine habitat types in the watershed.

Surveys for the species are primarily conducted in relation to pre-construction survey requirements for Clean Water Act (CWA) permits, as well as state and local authorizations (Appendix A). Based on analyses of TDEC Natural Heritage Data, CWA permit reviews, and other data sources, the Service and Tennessee Division of Natural Heritage ranked habitat quality and species occurrence data to develop guidance for future recovery efforts. These data were used to characterize Nashville crayfish population segments and identify the status of crayfish populations throughout the Mill Creek watershed (Figure 2).

Currently, the TFO and the Nashville Zoo are considering implementing a translocation study in a pond on an unnamed tributary (UT) to Sevenmile Creek on the zoo property. Three other potential translocation sites are being evaluated: two in the Sevenmile Creek watershed at the Ellington Agricultural Center and the Edmonson Pike Library stormwater retention pond, and one in the Owl Creek watershed.

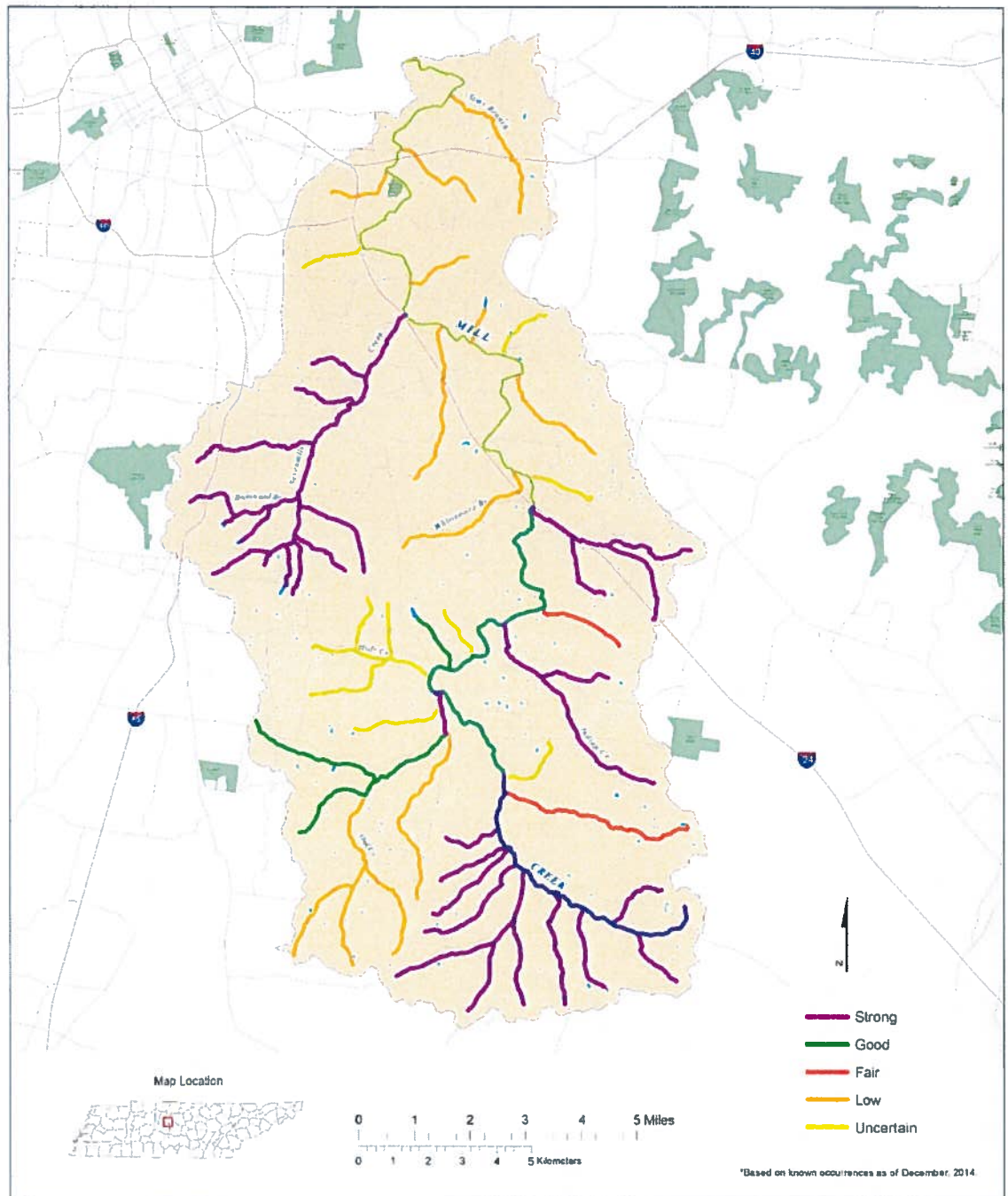
**e. Habitat:**

Observations made by biologists during numerous pre-project surveys for the species indicate that adult Nashville crayfish occur in various habitats in streams with slab rocks or other debris for cover. Although they primarily utilize riffle habitat, they are typically found in areas with slower flow velocities (i.e., riffle/runs, pools). Juveniles are most often found along the margins of the stream in slower flow where beds of aquatic vegetation provide cover.

In their 2009 report, the Tennessee Division of Natural Areas (TDNA) identified “preferred habitat that includes slabrock over bedrock or cobble substrates in free-flowing streams. “At least three exceptions involving small impoundments have been reported (Carpenter 2004; DNA Biotics 2009; Walton 2008).

On May 8, 2002, the TFO issued a biological opinion for an incidental take permit for a residential development on an unnamed tributary to Mill Creek. A five acre impoundment on the development site was considered to be unsuitable as habitat for the Nashville crayfish. However, draining of the impoundment had the potential for adverse effects to the species and its habitat downstream. A pre-draining survey was recommended because a small area of rock habitat was found in the impoundment. That survey and subsequent surveys conducted during the draining process yielded a total of more than 800 Nashville crayfish. Individuals were found throughout the pond in the area with slab rock and in areas with silt and mud substrate.

Figure 2. Assumed Status of Nashville Crayfish Populations



Cook and Walton (2008) conducted a study to characterize habitat use by the Nashville crayfish in Mill Creek. During that study, several individuals of the species were found in a retention pond adjacent to Owl Creek, a tributary to Mill Creek. Although there was a cut in a berm separating Owl Creek from the upstream end of the pond, there was no inflow or outflow from the tributary and



the shoreline had scattered limestone slab rocks. Additionally, in 2010, a stormwater impoundment at the Century Center development on Sims Branch was dredged to remove excessive sediment deposits. Pre-construction surveys revealed numerous Nashville crayfish individuals within the impoundment associated with rock armoring of the basin.

## **2. Five-Factor Analysis**

### **a. Present or threatened destruction, modification, or curtailment of habitat or range:**

The primary threat to the continued existence of the Nashville crayfish is still development in the Mill Creek drainage that results in destruction or alteration of the aquatic habitat. The population of Davidson County has grown by 5.1 percent between 2010 and 2013. Adjacent Williamson County has grown by 8.6 percent in the same time period. As Nashville and surrounding areas have grown, commercial and residential developments have increased within the Mill Creek drainage.

Areas in the upper reaches of the Mill Creek drainage that were once rural agricultural areas are now being developed for residential purposes. Development often results in removal of riparian vegetation and canopy cover over the stream. Runoff from denuded areas can result in heavy input of sediment into the stream and lack of canopy cover which may result in bank collapse, excessive in-stream sediment deposition, and increased water turbidity and temperatures. Sediment has been shown to abrade and or suffocate bottom-dwelling algae and other organisms by clogging gills and reducing aquatic insect diversity and abundance (Waters 1995).

Highway and road construction, as well as utility line construction and rights-of-way maintenance, within and adjacent to streams may alter or destroy habitat. Short-term dewatering to excavate trenches for utility lines may result in temporary loss of habitat. Sediment settling and filling in crevices and interstitial spaces under slab rocks may result in increased Biological Oxygen Demand (BOD) and longer term or permanent loss of habitat for crayfish (Cook and Walton 2008).

Another significant threat to the species' continued existence is the improper use or overuse of lawn pesticides and fertilizers. Intentional or inadvertent application of chemicals to the stream or runoff from yards after application has resulted in significant mortality of aquatic organisms, including Nashville crayfish. We receive periodic reports of mortality of stream fauna that likely resulted from input of pesticide into streams in the Mill Creek drainage. This threat is likely to increase in the future as residential development increases.

To avoid direct adverse impacts to the crayfish and its habitat, developers increasingly utilize directional boring under the stream as a means of accomplishing crossings for utility and communication lines; however, if not done properly, boring can cause fracturing of the stream bottom. This can result in release of bentonite and other slurries, as well as toxic materials from the bore hole into the stream. Dewatering of short or long reaches of the stream channel downstream from the fracture may also occur. Dewatering can be permanent if the fracture causes the entire surface flow to go underground.

Materials released into the stream from bore holes range from inert slurries to potentially toxic chemicals and lubricants; however, inert slurry, if released in large amounts, could result in mortality to crayfish and other benthic fauna by smothering adults and juveniles. During installation of fiber optic cables in 2000 in the Mill Creek drainage, several incidents of fracturing occurred resulting in the release of large amounts of bentonite slurry into the streams. In 2013, a Piedmont Natural Gas Pipeline boring under Sevenmile Creek impacted its tributary, releasing a bentonite slurry which resulted in mortality of six individuals. Due to these incidents, areas where known bedrock fracturing potential exist are now being trenched (surface cut) for projects involving utility line crossings.

**b. Overutilization for commercial, sporting, scientific, or educational purposes:**

This factor was considered to be a potential threat to the Nashville crayfish if circumstances necessitated designation of critical habitat, and therefore, publication of locations of Nashville crayfish populations. Although critical habitat was not designated for the species, we have received reports over the past five years (2010-2015) that fish and aquatic invertebrates, including Nashville crayfish, are being harvested from Mill Creek for food. We do not currently know the extent to which this is occurring, but if it is widespread, it could pose a significant threat to the species.

**c. Disease or predation:**

This factor was determined to be inapplicable to the Nashville crayfish at the time of its listing. We have no new information indicating that disease or predation has become a significant threat to the species; however, porcelain disease (*Thelohania contejeani*), known from crustaceans in Australia, may pose a threat if it is accidentally introduced in the Mill Creek watershed from the pet trade (see 2(e), below). There is anecdotal evidence that porcelain disease may have been observed in *Cambarus sphenoides* on the Cumberland Plateau. Competition or predation by released non-native crayfish could potentially pose a threat in the future (Bizwell and Mattingly 2010). Urbanization may result in increased numbers of scavengers such as raccoons that might prey on aquatic organisms. We currently have no information to indicate that disease or predation are threats to this crayfish.

**d. The inadequacy of existing regulatory mechanisms:**

In addition to the federal listing, the Nashville crayfish is listed as Endangered by the State of Tennessee. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), "...it is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered Or Threatened Species state the following: except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such

species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna.

Potential collectors of this species would be required to have a state collection permit. TWRA regulates the collection of aquatic fauna for scientific and other purposes. TWRA has regulations in place to address the collection of baitfish, including amphibians and crayfish, which specifically prohibits the taking of and possession of crayfish from Mill Creek and its tributaries in Davidson and Williamson Counties (Rule 1660-1-26-.04). The Tennessee Fish and Wildlife Commission also issued a proclamation (13-15) which stated that the collection of crayfish from Mill Creek in Davidson and Williamson Counties is specifically prohibited. It is also prohibited to possess or use crayfish for bait in Mill Creek which is key to preventing accidental introductions of non-native species.

No current state laws provide specific protection for the species' habitat. However, the Clean Water Act (CWA) of 1977 (33 U.S.C. 1251 et seq.) and the Tennessee Water Quality Control Act of 1977 provide water quality protections for streams in the state.

Agencies implementing these laws routinely issue notices of violation (NOVs) when actions are reported that have adverse impacts on waters in the state. Notices of violation are typically issued after the fact—i.e., after destruction or alteration of the species and habitat has occurred. Agencies are not staffed to oversee, supervise, or inspect all of the actions for which permits have been issued. Also, penalties levied on violators by the state are likely not severe enough to deter future violations. Even if more drastic enforcement action is taken by federal agencies, the time between the violation and conclusion of the law enforcement action is likely long enough to suppress the deterrent effect of the penalty.

TDEC and Metropolitan Nashville Water Services (MNWS) routinely issues CWA NOVs for incidents in the Mill Creek watershed. Service Law Enforcement personnel have assisted in numerous investigations; however, formal prosecutions are rarely pursued. In 2011, a contractor constructing a replacement sewage force main bypassed a section of an existing sewage forcemain by pumping past the section of forcemain to be replaced. Over the extended holiday weekend, the pump failed releasing a significant amount of sewage to Mill Creek. Crayfish mortality was observed; however, Service LE did not pursue an ESA enforcement action since this was an accidental release.

Although there have been over 30 NOVs issued in the Mill Creek watershed since 2009, state and federal water quality laws have not been used to their full potential in preventing pollution from development activities, and municipal, and industrial sources. Portions of Mill Creek and some of its tributaries are currently listed on the Tennessee Department of Environment and Conservation's impaired stream list (TDEC Draft 2014). Impairments include low dissolved oxygen, siltation, other anthropogenic habitat alterations, *Escherchia coli*, total phosphorus, nitrate-nitrite, and propylene glycol.

Since listing, section 7 of the Act has required Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect the species. However, the lack of Federal authority over the many actions likely impacting Nashville crayfish habitat has become apparent. Many of the threats facing the Nashville crayfish (including those identified at the time of listing, during recovery planning, and since

development of the Recovery Plan) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from development) and, thus, may not result in section 7 consultation. Although the take prohibitions of section 9 of the Act do apply to these types of activities and their effects on the Nashville crayfish, enforcement of the section 9 prohibitions is difficult, at best. The Service is not informed when many activities are being considered, planned, or implemented; therefore, we have no opportunity to provide input into the design of the project or to inform project proponents of the need for a section 10 permit. Unlike higher profile species, conservation of the Nashville crayfish is not valued by most of the public to the extent that citizens would report to the Service the likelihood of habitat destruction or illegal taking. A non-regulatory approach to providing for conservation of the Nashville crayfish may be most effective in alleviating threats and providing for conservation of the crayfish.

The TFO has actively cooperated with section 10 permittees on various projects which required survey and/or translocation efforts for the species. In 2011, we recommended new conditions for these permits which would enable more efficient and thorough habitat assessments and documentation.

The TFO has issued numerous biological opinions for adverse effects on Nashville crayfish populations within Tennessee which identified incidental take (Appendix B). These BOs contain specific terms and conditions to prevent and/or lessen potential impacts to water quality, habitats, and the species. Additionally, the TFO and USACE completed a programmatic section 7 Biological Opinion in 2015 that would cover routine CWA permit issuances in the watershed.

**e. Other natural or man-made factors affecting the species' continued existence:**

The Nashville crayfish's limited geographic range and apparent small population size leaves the species extremely vulnerable to localized extinctions from accidental toxic chemical spills or other stochastic disturbances. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007).

Potential sources of such spills include accidents involving vehicles transporting chemicals over road crossings of streams inhabited by Nashville crayfish and accidental or intentional release into streams of chemicals used in industrial, agricultural, or residential applications. Dead crayfish, including Nashville crayfish, have been collected by various agency personnel downstream from construction sites and sewage releases on numerous occasions in the past. In 2010 and 2011, discharges of propylene glycol de-icing fluids from the runways and tarmac at the Metropolitan Nashville International Airport adversely affected Sims Branch. Agency personnel responded and located affected Nashville crayfish. An attempt to translocate these individuals to the Cumberland River Aquatic Center failed as the specimens died during transport. TDEC and the TFO conducted a Natural Resource Damage Assessment (NRDA) and developed specific recommendations for stormwater treatment, monitoring, and compliance to the Metropolitan Nashville Airport Authority (MNAA). Civil Clean Water Act (CWA) penalties were also assessed by TDEC. In cooperation with the Service and our partners, MNAA made substantial improvements to the stormwater collection and treatment

system at their facility. The TFO also provided specific recommendations to TDEC in the revision of MNAA's National Pollutant Discharge Elimination System permit after the incidents.

Most crayfish experts now believe the introduction of invasive crayfish species such as the rusty crayfish (*Orconectes rusticus*) to be the greatest threat to native species, especially species with small distributions. In east Tennessee, there have been several introductions; the most serious is the Kentucky River crayfish (*O. juvenilis*) which has replaced the surgeon crayfish (*O. forceps*) in most of the Holston River system above Cherokee Reservoir. It is conceivable that one of these extremely aggressive species could easily be introduced into the Mill Creek system and, once established, there is no known method to remove them. A simple aquarium release of a single ovigerous female or other live specimens would be detrimental to the Nashville crayfish. The species persists despite current impacts in the Mill Creek drainage, but the cumulative effects of current and future development may pose a significant threat to the species' survival.

#### **D. Synthesis**

The species can be found in large numbers at certain locations within the Mill Creek drainage and the species has been found in several additional tributaries to Mill Creek over the past 20 years. Although the Metropolitan Nashville area is experiencing significant growth, with numerous residential, commercial, utility, and other infrastructure developments occurring in the watershed, these populations have been documented to be stable or increasing in size. Additionally, there have been consistent stormwater and sediment inputs to the Mill Creek watershed, as well as frequent spills/releases of raw sewage and hazardous substances, yet the Nashville crayfish persists in high numbers. The species exhibits a high degree of resistance to disturbance, indicating that the species has a low susceptibility to threats and high degree of stability.

The TFO is actively engaged with federal, state, and local agencies, and NGOs to address potential habitat loss for the species. Development, siltation, pollution and nutrient, herbicide and pesticide run-off are all contributing factors to habitat degradation. This 108-square mile network of streams, creeks and tributaries that makes up the Mill Creek watershed drains southeastern Davidson County and northeastern Williamson County into the Cumberland River. Of Mill Creek's 20 total miles, more than 16 are listed as "impaired" by the state. Cooperative restoration projects have also been implemented.

Project leaders are organizing the Mill Creek Watershed Association for individuals interested in preserving the area. Restoration efforts include community-driven cleanups of Mill Creek and stenciling "No Dumping" signs on the more than 8,000 storm drains in the watershed. Nashville Zoo staff initiated the Nashville Crayfish Project in collaboration with TDEC, TWRA and the Service. One of the project's main objectives focuses on involving the community in Mill Creek's revitalization, simultaneously improving and protecting crayfish habitat. Nashville Zoo is also developing a breeding program for the crayfish. The Zoo hopes to have the program established and Nashville crayfish on display in the Unseen New World exhibit next year.

Due to the naturally limited range of the species and increasing development in the watershed, we believe the species will continue to experience unquantifiable threats.



However, the threats that species is experiencing are having less of an impact than previously believed; evidence indicates the species is resilient to these perturbations and populations appear to be stable, with some populations increasing. Therefore, we believe that reclassification to a threatened designation should be considered.

### **III. RESULTS**

#### **A. Recommended Classification**

    X     **Downlist to Threatened**

### **IV. RECOMMENDATIONS FOR FUTURE ACTIONS**

1. Develop objective, and measurable recovery criteria, taking into account evidence that the Nashville crayfish is endemic to the Mill Creek drainage and highly resilient to perturbation.
2. Conduct studies to determine the extent to which Nashville crayfish can survive and perpetuate itself in man-made ponds similar to habitats where the species has been previously collected. If the results of such research indicate that the species could utilize such habitat, investigate the feasibility of establishing Nashville crayfish in man-made retention ponds adjacent to streams in the Mill Creek drainage. If implemented, the ponds should be protected from water quality degradation and other human intrusion to the maximum extent possible.
3. Continue to work with the USACE, TDEC, and municipal and county governments to incorporate protective measures for the Nashville crayfish and its habitat into permits issued for development activities in the Mill Creek drainage.
4. Continue working with representatives at the Nashville Zoo and other partners to develop outreach and educational programs to promote pride in Mill Creek and protection of the Nashville crayfish among the residents in the drainage.
5. Continue support for partners implementing a long-term monitoring program for the species. Track trends in numbers, distribution, and recruitment of the species in relation to development in the drainage. In addition to providing trend data, this would provide the basis for post-delisting monitoring should the species reach recovery.
6. Investigate the extent to which the Nashville crayfish is being exploited for food and bait.
7. Conduct research to determine if urbanization in the Mill Creek drainage is resulting in elevated numbers in populations of potential predator species (e.g.,

raccoons, muskrats). Determine if predation on Nashville crayfish is increasing as a result.

8. Work with developers in the Mill Creek drainage to reduce indirect impacts to the streams during development and encourage them to include protection of riparian zones and establishment of green space in future developments in the drainage.
9. Evaluate lands critical to the survival of the species in priority segments of the watershed and work with land trusts and similar organizations to provide incentives for conservation.
10. Evaluate underutilized, previously developed riparian areas for restoration and enhancement.
11. Work directly with MNAA regarding potential enhancements to lands and streams under its control but outside the regular EPA and TDEC regulatory framework.
12. Work directly with Metro Nashville Parks to ensure that uses associated with their lands in the Mill Creek watershed are conducive to protection of the Nashville crayfish, and assist evaluation of additional land parcels that could be brought under their stewardship.

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**U.S. FISH AND WILDLIFE SERVICE**  
**5-YEAR REVIEW OF THE NASHVILLE CRAYFISH**

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

☒ Downlist to Threatened

☐ Uplist to Endangered

☐ Delist

☐ No change is needed

Review Conducted By: Steven Alexander, Tennessee Ecological Services Field Office

**FIELD OFFICE APPROVAL:**

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve: Mary E Jennings Date: Jan. 27, 2017

**REGIONAL OFFICE APPROVAL:**

Lead Regional Director, U.S. Fish and Wildlife Service

Approve:  ARD-ES Date: 2.7.17

**Appendix A. Project Sweeps for *Orconectes shoupi* in 2013 - 2015.**

<b>Date</b>	<b>Site</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Number Encountered</b>	<b>Number Collected</b>
06/03/14	UT to Mill Creek	36.03659	-86.66602	0	0
06/03/13	UT to Mill Creek	36.037264	-86.667627	0	0
06/05/13	UT to Mill Creek	36.03659	-86.66602	0	0
06/05/13	UT to Mill Creek	36.037264	-86.667627	0	0
06/14/13	UT to Mill Creek	36.04007	-86.67626	0	0
06/19/13	UT to Whittemore Branch	36.04298	-86.69215	0	0
06/27/13	UT to Whittemore Branch	36.04343	-86.70013	0	0
06/27/13	UT to Whittemore Branch	36.043932	-86.699722	0	0
06/27/13	UT to Whittemore Branch	36.044045	-86.699717	0	0
07/01/13	UT to Whittemore Branch	36.04343	-86.70013	0	0
07/01/13	UT to Whittemore Branch	36.043932	-86.699722	0	0
07/01/13	Stream 8	36.044045	-86.699717	0	0
07/03/13	Sevenmile Creek	36.052192	-86.745033	0	0

07/03/13	Shasta Branch	36.049298	-86.738426	0	0
<b>07/04/13</b>	<b>Sevenmile Creek</b>	<b>36.052192</b>	<b>-86.745033</b>	<b>16</b>	<b>16</b>
07/04/13	Shasta Branch	36.049298	-86.738426	0	0
07/05/13	Sevenmile Creek	36.052192	-86.745033	0	0
07/05/13	Shasta Branch	36.049298	-86.738426	0	0
07/12/13	UT to Brentwood Branch	36.05469	-86.76958	0	0
07/16/13	Stream 6A	36.04343	-86.70013	0	0
07/16/13	Stream 6B	36.043932	-86.699722	0	0
07/16/13	Stream 8	36.044045	-86.699717	0	0
07/16/13	UT to Brentwood Branch	36.05469	-86.76958	0	0
07/26/13	Shasta Branch	36.049298	-86.738426	0	0
07/26/13	Sevenmile Creek	36.052192	-86.745033	0	0
09/24/13	Shasta Branch	36.049298	-86.738426	0	0
09/24/13	Sevenmile Creek	36.052192	-86.745033	0	0
09/30/13	Sevenmile Creek	36.052192	-86.745033	6	0
5/28/14	Mill Creek	35.995060	-86.698425	76	0
5/28/14	Mill Creek	35.994514	-86.691521	83	0
5/29/14	Owl Creek	35.995060	-86.698425	25	0

5/29/14	Owl Creek	35.992493	-86.697906	34	0
6/2/14	Mill Creek	35.995060	-86.698425	212	0
6/2/14	Owl Creek	35.995060	-86.698425	89	0
6/3/14	Mill Creek	35.994514	-86.691521	33	0
6/3/14	Owl Creek	35.992493	-86.698425	3	0
6/5/15	Owl Creek	35.992493	-86.698425	11	0



## APPENDIX B

The following list includes previous biological opinions, issued for adverse effect and completed for Nashville crayfish populations within Tennessee, which identified incidental take:

<b>OPINIONS (year/number)</b>	<b>INCIDENTAL TAKE NUMBER</b>	<b>CRITICAL HABITAT</b>	<b>HABITAT</b>
1994/1	No more than 25% of the total number of individuals present in the project area	N/A	
2002/1	No more than 2% of the total number of individuals present in the project area	N/A	
2002/1	No more than 3 individuals at each crossing	N/A	
2002/1		N/A	No more than 0.5-ac of suitable habitat
2003/1	None specified	N/A	None specified
2004/1	No more than 5 individuals	N/A	
2008/2		N/A	No more than 0.5-ac of suitable habitat
2008/2		N/A	No more than 620 linear ft of suitable habitat
2009/1		N/A	No more than 3,145 linear ft of Mill Creek affected, resulting in the loss of 315 lf of suitable habitat

<b>2009/1</b>		<b>N/A</b>	<b>No more than 4,320 ft<sup>2</sup> of habitat at Mill Creek crossings or 1,120 ft<sup>2</sup> of habitat at the tributary crossings</b>
<b>2009/1</b>		<b>N/A</b>	<b>No more than the Nashville crayfish occupying 215 ft<sup>2</sup> of the bottom of the Sims Branch pond</b>
<b>2010/1</b>		<b>N/A</b>	<b>No more than 1,260 ft<sup>2</sup> of Nashville crayfish habitat</b>
<b>2011/1</b>	<b>No more than 20 individuals per year as a result of collection, holding, and relocation</b>	<b>N/A</b>	<b>Loss of 0.5% of suitable habitat from which crayfish are removed at all project sites per year</b>
<b>2011/1</b>	<b>No more than 2 individuals</b>	<b>N/A</b>	
<b>2012/5</b>		<b>N/A</b>	<b>No more than 45,654 ft<sup>2</sup> (6,906 linear ft) Nashville crayfish habitat</b>
<b>2013/4</b>		<b>N/A</b>	<b>No more than 4,466 ft<sup>2</sup> (1,833 linear ft) Nashville crayfish habitat</b>
<b>2015/2</b>		<b>N/A</b>	<b>All Nashville</b>

			<p>crayfish within 2,175 linear ft of suitable Nashville crayfish habitat (875 linear ft of this total were projects implemented under the first year of this programmatic consultation)</p>
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## **APPENDIX C: Summary of peer review for the 5-year review of the Nashville crayfish**

**A. Peer Review Method:** This document was collaboratively produced by staff at the Nashville Zoo, Tennessee Department of Environment, Tennessee Wildlife Resources Agency, and the Service.

**B. Peer Review Charge:** The U.S. Fish and Wildlife Service (Service) is conducting a 5-year review of the appropriateness of the current listing of the Nashville crayfish (*Orconectes shoupi*) as an endangered species under provisions of the Endangered Species Act of 1973, as amended (Act). On September 21, 2007 (72 FR 54057), we published a notice in the Federal Register announcing our intent to conduct this review on this species for which our office has the lead responsibility under section 4(c)(2)(A) of the Act. At that time, we requested any new information on the Nashville crayfish since the time of its listing in 1986. In order to support the Service's interest in making its decision based on the best available science, portions of the draft review need to be subjected to an appropriate level of peer review. Due to your expertise regarding this species, we request you peer review the attached portion of the document. We must receive your comments within 30 days of the date of the email (August 21, 2014) in order to consider them in our final review document.

The goals of peer review during this process are (1) to ensure that the best available biological data, scientifically accurate analyses of those data, and the reviews of recognized experts are used in the decision-making process; and (2) to indicate to the public, to other agencies, to conservation organizations, and to personnel within the Service that the best available data and scientific analyses were used in the decision-making process.

The following materials are enclosed for use during your review:

Peer Review in Endangered Species Act Activities – This July 1, 1994, Federal Register notice established a peer review process for all listing and recovery actions taken under the authorities of the Endangered Species Act.

The Biological Portion of the Draft 5-Year Review – This is the draft material that we hope you will review.

The Literature Cited Section of the Draft 5-Year Review – The list is enclosed.

**C. Summary of Peer Review Comments/Report:** No substantive comments were received from the peer reviewers. All editorial comments received on previous drafts were incorporated.

**D. Response to Peer Review:** None needed.